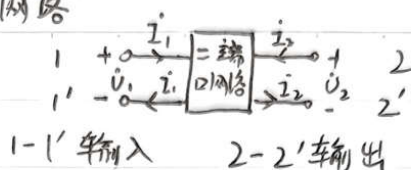


第十六章

二端口网络

第十六章 二端口网络

16.1 二端口网络



本章为电阻, 电容, 电感
受控源(无独立源)的二端口
(初始条件为0)

复杂电路 \rightarrow 二端口网络 复杂二端口 \rightarrow 多个简单二端口

16.2 二端口的方程和参数



六种方程

$$\begin{matrix} U_1 \Leftrightarrow U_2 & U_1 \Leftrightarrow I_2 & U_1 \Leftrightarrow I_1 \\ I_2 \Leftrightarrow U_2 & I_2 \Leftrightarrow I_1 & I_2 \Leftrightarrow I_1 \end{matrix}$$

1. Y参数 $\begin{matrix} I_1 \\ I_2 \end{matrix} \begin{matrix} U_1 \\ U_2 \end{matrix}$

$$\begin{cases} I_1 = Y_{11}U_1 + Y_{12}U_2 \\ I_2 = Y_{21}U_1 + Y_{22}U_2 \end{cases} \quad \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} U_1 \\ U_2 \end{bmatrix} = Y \begin{bmatrix} U_1 \\ U_2 \end{bmatrix}$$

$$Y_{11} = \frac{I_1}{U_1} \Big|_{U_2=0} \quad Y_{21} = \frac{I_2}{U_1} \Big|_{U_2=0}$$

$$Y_{12} = \frac{I_1}{U_2} \Big|_{U_1=0} \quad Y_{22} = \frac{I_2}{U_2} \Big|_{U_1=0}$$

转移导纳 输入导纳 转移导纳

(Y): 短路导纳参数, $Y_{12} = Y_{21}$

若 $Y_{11} = Y_{22}$, 则为对称二端口, 满足互易定理, 互易

2. Z参数方程 $\begin{matrix} U_1 \\ U_2 \end{matrix} \begin{matrix} I_1 \\ I_2 \end{matrix}$

$$\begin{cases} U_1 = Z_{11}I_1 + Z_{12}I_2 \\ U_2 = Z_{21}I_1 + Z_{22}I_2 \end{cases} \quad \begin{bmatrix} U_1 \\ U_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = Z \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$Z = Y^{-1} \quad Y = Z^{-1}$$

$$Z_{11} = \frac{U_1}{I_1} \Big|_{I_2=0} \quad Z_{21} = \frac{U_2}{I_1} \Big|_{I_2=0} \quad Z_{22} = \frac{U_2}{I_2} \Big|_{I_1=0} \quad Z_{12} = \frac{U_1}{I_2} \Big|_{I_1=0}$$

输入阻抗 转移阻抗 输入 转移

$Z_{12} = Z_{21}$, 对称 $Z_{22} = Z_{11}$ (Z): 开路阻抗参数

含有受控源 $Y_{12} \neq Y_{21}$, $Z_{12} \neq Z_{21}$

一些二端口不能用 Y, Z 描述

3. T参数方程 (传输参数方程)



$$\begin{cases} U_1 = A U_2 - B I_2 \\ I_1 = C U_2 - D I_2 \end{cases} \quad \begin{bmatrix} U_1 \\ I_1 \end{bmatrix} = T \begin{bmatrix} U_2 \\ -I_2 \end{bmatrix}$$

$$T = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \quad \text{反映输入和输出之间的关系}$$

$$A = \frac{U_1}{U_2} \Big|_{I_2=0} \quad C = \frac{I_1}{U_2} \Big|_{I_2=0} \quad B = \frac{U_1}{-I_2} \Big|_{U_2=0} \quad D = \frac{I_1}{-I_2} \Big|_{U_2=0}$$

转移电压比 开路参数 (断 I_2) 转移导纳/阻抗 短路参数 (U_2 短) 电流比

$$A = -\frac{Y_{22}}{Y_{21}} \quad B = -\frac{1}{Y_{21}} \quad C = Y_{12} - \frac{Y_{11}Y_{22}}{Y_{21}} \quad D = -\frac{Y_{11}}{Y_{21}}$$

互易二端口 $AD - BC = 1$ 对称: $A = D$

4. H参数方程 (混合参数方程) 常用于晶体管等效电路

$$\begin{cases} U_1 = H_{11}I_1 + H_{12}U_2 \\ I_2 = H_{21}I_1 + H_{22}U_2 \end{cases} \quad \begin{bmatrix} U_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ U_2 \end{bmatrix} = H \begin{bmatrix} I_1 \\ U_2 \end{bmatrix}$$

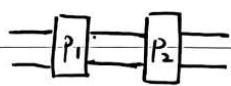
$$H_{11} = \frac{U_1}{I_1} \Big|_{U_2=0} \quad H_{21} = \frac{I_2}{I_1} \Big|_{U_2=0} \quad H_{12} = \frac{U_1}{U_2} \Big|_{I_1=0} \quad H_{22} = \frac{I_2}{U_2} \Big|_{I_1=0}$$

短路输入阻抗 短路转移电流比 开路转移电压比 开路输入导纳

互易: $H_{12} = -H_{21}$ 对称: $H_{11}H_{22} - H_{12}H_{21} = 1, H_{12} = -H_{21}$

16.5 二端口的连接

1. 级联



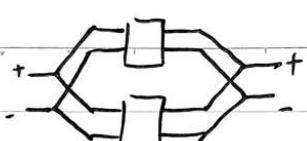
$$T = T'' T' \quad (\text{矩阵相乘})$$

$$\begin{bmatrix} A'' & B'' \\ C'' & D'' \end{bmatrix} \begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}$$

端口条件不会被破坏

KOKUYO

2. 并联

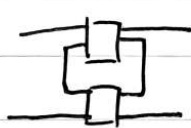


(并联可能破坏二端口, 致下式不成立)

$$Y = Y' + Y''$$

(具有公共端的二端口不会破坏端口条件)

3. 串联



$$Z = Z' + Z''$$

串联二端口条件可能被破坏, 上式不成立

具有公共端口的二端口不会破坏